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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04R 9/06 — A1

(11) International Publication Number: WO 99/12387

(43) International Publication Date: 11 March 1999 (11.03.99)

(21) International Application Number: PCT/GB98/02532

(22) International Filing Date: 24 August 1998 (24.08.98)

(30) Priority Data:

9718730.6	4 September 1997 (04.09.97)	GB
9727193.6	23 December 1997 (23.12.97)	GB

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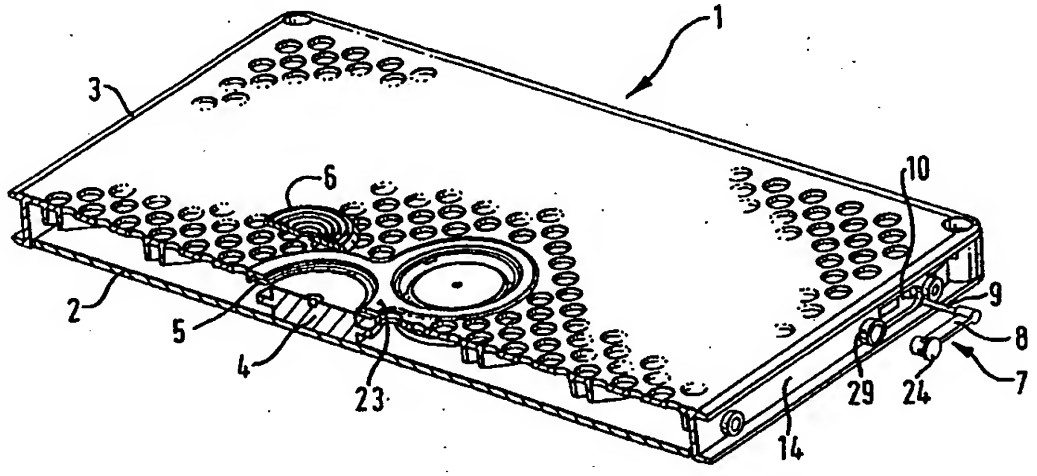
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: LOUDSPEAKERS



(57) Abstract

An assembly comprising a resonant panel acoustic radiator, a body from which the acoustic radiator is suspended, at least one vibration exciter on the radiator to launch bending waves into the radiator to cause it to resonate to produce an acoustic output, and means on the body suspending the radiator for free movement relative thereto.

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TITLE: LOUDSPEAKERS

DESCRIPTION

TECHNICAL FIELD

The invention relates to loudspeakers of the kind in which an acoustic output is produced by launching bending waves into an acoustic radiator comprising a resonant panel. Such loudspeakers are described in International patent application WO97/09842 of New Transducers Limited.

It is an object of the present invention to provide a modular assembly comprising a resonant panel acoustic radiator for use as a loudspeaker or as a drive unit for use in a loudspeaker.

DISCLOSURE OF INVENTION

Accordingly the present invention provides an assembly comprising a resonant panel acoustic radiator, a body suspending the acoustic radiator, at least one vibration

exciter on the radiator to launch bending waves into the radiator to cause it to resonate to produce an acoustic output, and means on the body suspending the radiator for free movement relative thereto.

The body may take the place of a chassis in a conventional loudspeaker drive unit, although in the present invention the body is usually not required to be of the same degree of weight and rigidity as is required with a conventional pistonic drive unit. The body (hereinafter chassis) may be a lightweight frame-like structure.

The chassis may be such as to enclose the radiator panel. The chassis may be a tray-like member having a surrounding peripheral lip. The chassis may be of light weight and may, for example, be a plastics moulding. The chassis may be an open frame, or may be perforate.

Means may be provided for freely suspending the edges of the acoustic radiator on the chassis. The suspension may be such as to allow free movement of the acoustic radiator in directions normal to the plane of the radiator (it will usually be a flat plate) while preventing movement of the radiator in its plane. The suspension may comprise arms or links hinged at one end to the chassis and at the other end to the radiator for swinging movement about respective parallel axes at opposite ends of the arms or links. Such arms or links may be provided on all four sides of a generally rectangular radiator. The suspension arms or links on opposite sides of the radiator may be attached near to diagonally opposed corners of the

radiator. The connections of the arms or links to the radiator may be by means of resilient foam pads, e.g. of rubber or a rubber-like material, which are fixed to the radiator, e.g. by means of an adhesive, near to its corners and which receive hinge pins provided on the ends of the arms or links.

The chassis may be formed with a conduit in which services such as electrical input leads to the vibration exciter(s) may be located. The conduit may be in the form of a channel extending round the periphery of the chassis. The chassis may be formed with means whereby it can be supported in position to form a loudspeaker or such that more than one of the assemblies can be linked together to form a larger loudspeaker unit. Thus the corners of the chassis may be formed with bores for receiving linking members comprising respective pegs which are frictionally received in the bores to hold two or more of the assemblies together edge-to-edge to form a large loudspeaker panel.

A linking member comprising two pegs may be used to join two adjacent modular assemblies, and a linking member comprising four pegs may join the corners of four adjacent modular assemblies.

The linking member may establish an electrical link between adjacent modular assemblies as well as providing the mechanical linkage. To provide an electrical connection, the pegs of each linking member may comprise outer and inner connectors and means electrically connecting the outer and inner connectors of one peg to the

outer and inner connectors of the other pegs of the linking member. To establish a serial electrical connection between the modular assemblies, the inner connector of one peg may be electrically connected to the outer connector of another peg of the linking member. For a parallel connection, the inner conductors of the pegs of the linking member may be electrically connected and the outer conductors of the pegs may be electrically connected.

The electrical signal may be carried between the modular assemblies by making two surfaces of the chassis or frame moulding electrically conductive. This may be achieved by embedding or otherwise applying electrical conductors in the channel, for example by printing, e.g. in the upper and lower surfaces of the peripheral lip of the chassis. A parallel pair of conductors may be provided. Each conductor is preferably co-extensive with the surrounding peripheral lip of the chassis and may have a connector pad provided at each of its four corners. The connector pads are preferably received in the said bores at each corner of the chassis and which receive the linking members. Alternatively, two surfaces of the frame moulding can be made conductive during the moulding process, e.g. by advanced injection moulding techniques. In either case the conductive surfaces of the frame moulding may provide a busbar for electrical connectivity between each of the following pairs, namely adjacent resonant panel acoustic radiators, exciter(s) and frame, and each two resonant panel acoustic radiator assembly to the outside world.

The resonant panel acoustic radiator may comprise a member having capability to sustain and propagate input vibrational energy by bending waves in a least one operative area extending transversely of thickness to have resonant mode vibration components distributed over said at least one area and have predetermined preferential locations or sites within said area for vibration exciter means and having an exciter mounted on said member at one of said locations or sites to vibrate the member to cause it to resonate forming an acoustic radiator which provides an acoustic output when resonating.

The or each vibration exciter may be of the kind described in our International patent application WO98.31188, which describes a vibration exciter which can be freely or resiliently suspended on a support, e.g. the body or chassis of the present invention.

BRIEF DESCRIPTION OF DRAWINGS

The invention is diagrammatically illustrated, by way of example, in the accompanying drawings, in which:-

Figure 1 is a perspective cross-sectional view of a modular loudspeaker drive unit;

Figure 2 is an exploded perspective view of the modular assembly of Figure 1;

Figure 3 is a perspective view showing the interior face of a basket or chassis for the modular assembly of Figure 1, and

Figure 4 is a perspective view of a resonant acoustic radiator panel for the modular assembly of Figure 1;

Figure 5 is a perspective view of two interconnected modular assemblies;

Figure 6 is a perspective view of four interconnected modular assemblies;

Figure 7 is an enlarged scrap perspective view of a linking member interconnecting two modular assemblies;

Figures 8 is an enlarged scrap perspective view of a linking member and a corner of one modular assembly;

Figure 9 is an enlarged scrap perspective view of a linking member interconnecting four modular assemblies;

Figure 10 is an enlarged scrap perspective view of a linking member and the corners of two modular assemblies;

Figure 11a,11b,11c are respective perspective views of parallel and serial linking members;

Figure 12 is an exploded perspective view of the modular assembly of Figure 1 with the addition of a pair of busbars;

Figure 13 is a perspective view of a connector pad, and

Figure 14 is a partial cross-section through a pair of modular assemblies and a linking member connecting them together.

BEST MODES FOR CARRYING OUT THE INVENTION

Figures 1 to 4 illustrate a flat generally rectangular modular loudspeaker drive unit assembly (1) comprising a generally rectangular stiff lightweight resonant acoustic radiator panel (2), e.g. of the kind described in International patent application WO97/09842 mounted in a

surrounding generally rectangular body in the form of a chassis or basket (3) with a pair of vibration exciters (4) mounted on the panel (2) to launch bending waves into the panel (2) to cause it to resonate to provide an acoustic output.

The chassis (3) encloses the radiator panel (2) and is formed with a surrounding outwardly facing conduit (14) defined between outwardly projecting flanges (11) in which services such as electrical input leads to the vibration exciters (4) can be located. The conduit (14) is thus in the form of a channel extending round the periphery of the chassis (3).

Figures 1 and 2 also illustrate a means (7) for freely suspending the acoustic radiator (2) on the chassis (3) by its edges. The suspension (7) comprises arms or links (8) hinged at one end to the chassis (3) and at the other end to the radiator (2) for swinging movement about respective parallel axes at opposite ends of the arms or links (8). The connections of the arms or links (8) to the radiator (2) is by means of resilient foam pads (10) each formed with a bore (26), which receive hinge pins (9) provided on one end of each of the arms or links (8). The other end of each arm or link (8) is formed with a cylindrical boss (24) received in a corresponding aperture (29) on the chassis (3). The suspension (7) is such as to allow free movement of the acoustic radiator (2) in directions normal to the plane while preventing movement of the radiator (2) in its plane.

As shown in Figure 2, a pair of inertial electro-dynamic vibration exciters (4) are coupled to the radiator (2) to launch bending wave vibration into the radiator. The exciters (4) are suspended on the chassis (3) such that their motion normal to the plane of the radiator (2) is unimpeded and to prevent movement of the exciters in the plane of the radiator (2) whereby centring of the relatively movable parts of the exciters is ensured. This exciter suspension is the subject of International patent application WO98/31188.

This suspension resembles, at least in function, the spider commonly found in the drive units of conventional pistonic loudspeakers, and is in the form of a disc-like plate (5) having an inner portion attached to the exciter and an outer portion attached to the chassis, the inner and outer portions being separated such that the one can move normally with respect to the other and so that relative movement in the plane of the disc-like plate is prevented. This is achieved by forming the disc (5) with circumferential and radial slits (30,32) respectively to form a pair of curved limbs (33) the free ends (31) of which are attached to the chassis. For this purpose the chassis (3) is formed with a plate-like exciter locating portion (23) formed with opposed apertures (25) which align with and surround the respective exciters (4) and to which portion (23), the free ends (31) of the limbs (33) are attached. A heat sink (6) is attached to each exciter over the top of the plate (5), to assist in cooling the exciters

during use.

Figure 3 shows the interior face of the basket or chassis (3). The chassis (3) is a tray-like member comprising a perforate plate-like member (34) having an upstanding rim (35) which carries the surrounding pair of outwardly extending flanges (11) which define the conduit (14). The chassis (3) is lightweight and may, for example, be a plastics moulding.

Figure 4 illustrates the positions of the resilient foam pads (10) on the acoustic radiator (2). The foam pads comprise bores (26) to receive hinge pins (9) provided on the ends of the arms or links (8) of the means (7) for suspending the edges of the acoustic radiator (2) on the chassis (3). The foam pads (10) are positioned on all four sides of the radiator (2) and the foam pads (10) on opposite sides of the radiator (2) are attached near to diagonally opposed corners of the radiator (2). The resilient foam pads (10) which may be of rubber or a rubber-like material, are fixed to the radiator (2), e.g. by means of an adhesive.

Figures 5 and 6 illustrate respectively the interconnection of the chassis (3) of two and four of the modular assemblies (1) of Figures 1 to 4. To this end the corners of the chassis are formed with bores (15) for receiving linking members (16,18) comprising respective pegs (17) which are frictionally received in the bores (15) to hold the two assemblies together edge-to-edge to form a large loudspeaker panel. The linking member (16) comprises

two parallel pegs and is used to hold two modular assemblies (1) together. The linking member (18) comprises four parallel pegs arranged in a square formation. A combination of the linking members (16,18) may be used to hold four assemblies together.

Figure 7 illustrates the detail of the linking member (16) of Figure 5 which comprises two parallel pegs (17',17") interconnected by a web or arm (27). The two pegs (17',17") are frictionally received in the bores (15',15") to interconnect two modular assemblies (1) of the kind shown in Figures 1 to 4.

Figures 8 to 10 illustrate the detail of the linking member (18) of Figure 6. As can best be seen in Figure 8, the linking member (18) comprises four pegs (17) interconnected by a cruciform web (28). The web (28) comprises a generally rectangular central body (38) and four arms (39) which extend from the four corners of the rectangular body (38). Each peg (17) is frictionally received in a bore (15) at the corner of the chassis (3) of a modular assembly (1) of Figures 1 to 4.

Figure 9 illustrates how four modular assemblies (1) are interconnected by a linking member (18) which has each of its pegs (17) frictionally received in bores (15) at the corners of the modular assemblies (1).

Figure 10 illustrates the details of the bores (15) which frictionally receive the pegs (17). The bores (15) are generally cylindrical with a rectangular groove (40) to receive the arm (39) of the web (28) which interconnects

the pegs (17).

Figures 11a,11b and 11c are perspective views of series and parallel connected linking member (16), which are used to establish an electrical link between adjacent acoustic radiators. As can be seen in Figure 11c, the linking member (16) comprises two pegs (17',17") each of which comprise an outer electrical connector (20), and an inner electrical connector (19) arranged in a co-axial configuration.

In Figure 11a, a serial electrical connection between the assemblies (1) (not shown) is established by electrically connecting via conductor wires (21), the inner connectors (19,19') of each peg (17',17") to the outer connectors (20,20') of the other peg (17',17"). In Figure 11b, a parallel connection is established by electrically connecting via conductor wires (21) the inner conductors (19,19') of each peg (17',17") and by electrically connecting via conductor wires (21) the outer conductors (20,20') of each peg (17',17").

Figure 12 illustrates the modular assembly (1), with an opposed pair of conductor rails or busbars (12,13), which are mounted on or located in or embedded in the chassis (3) to surround the chassis. One conductor (12) may be positively charged and the other conductor (13) may be negatively polarised to carry the electrical signal between adjacent assemblies (1). The conductors (12,13) are co-extensive with the peripheral lip (11) of the chassis (3) and have connector pads (22) at each corner and

which pads are arranged to fit into the bores (15) at each corner of the chassis (3), for electrical contact with the linking members illustrated in Figures 11a,11b and 11c above.

Figure 13 illustrates the detail of a connector pad (22) at the corner of a conductor (12). The connector pad (22) comprises a circular ring (36) and a link (37), attaching the ring (36) to the connector pad (22).

As shown in Figure 14, the busbars (12,13) are electrically connected to the electrical connections of the linking members (16,18) by means of screws (41) which engage threaded inserts (42) in the linking members to hold the linking members in the bores (15) in the assemblies (1). The screws (41) thus ensure both the mechanical connection of the assemblies (1) and the electrical connections between the assemblies.

INDUSTRIAL APPLICABILITY

The invention thus provides a simple manner of adapting resonant panel acoustic radiators for mass production and for electrically connecting interlinked acoustic radiators.

CLAIMS

1. An assembly characterised by a resonant panel acoustic radiator, a body from which the acoustic radiator is suspended, at least one vibration exciter on the radiator to launch bending waves into the radiator to cause it to resonate to produce an acoustic output, and means on the body suspending the radiator for free movement relative thereto.

2. An assembly according to claim 1, characterised in that the body encloses the radiator panel.

3. An assembly according to claim 2, characterised in that the body is a tray-like member having a surrounding peripheral lip.

4. An assembly according to claim 7, characterised in that the tray-like member is perforate.

5. An assembly according to any preceding claim, characterised by suspension means coupling the edges of the acoustic radiator to the body.

6. An assembly according to claim 5, characterised in that the radiator is substantially flat and in that the suspension is such as to allow free movement of the acoustic radiator in directions normal to the plane of the radiator while preventing movement of the radiator in its plane.

7. An assembly according to claim 6, characterised in that the suspension comprises links hinged at one end to the body and at the other end to the radiator for swinging movement about respective parallel axes at opposite ends of

the links.

8. An assembly according to claim 7, characterised in that the radiator is generally rectangular and in that the suspension links are provided on all four edges of the radiator.

9. An assembly according to claim 8, characterised in that the suspension links on opposite edges of the radiator are attached near to diagonally opposed corners of the radiator.

10. An assembly according to any one of claims 7 to 9, characterised in that the connection of the links to the radiator is by means of resilient pads which are fixed to the radiator near to its corners and which receive hinge pins provided on the links.

11. An assembly according to any preceding claim, characterised in that the body is formed with a conduit in which electrical services are located.

12. An assembly according to claim 11, characterised in that the conduit is in the form of a channel extending round the periphery of the body.

13. An assembly according to any preceding claim, characterised in that the body is formed with means whereby the assembly can be linked to another such assembly.

14. An assembly according to claim 13, characterised in that the body has corners formed with bores, and characterised by linking members comprising respective pegs which are adapted to be received in the bores to hold a plurality of the assemblies together edge-to-edge.

15. An assembly according to claim 14, characterised in that the linking members are adapted to establish an electrical link between adjacent assemblies.

16. An assembly according to claim 14 or claim 15, characterised in that each linking member comprises two or more pegs each of which comprises connector pairs and means for electrically connecting the connector pairs of one peg to the connector pairs of the other pegs.

17. An assembly according to claim 16, characterised in that the connector pairs are concentric.

18. An assembly according to claim 17, characterised in that a serial electrical connection between the acoustic radiators is established by electrically connecting the inner connectors of each peg to the outer connectors of the other pegs.

19. An assembly according to claim 17, characterised in that a parallel electrical connection is established by electrically connecting the inner conductors of each peg together and by electrically connecting the outer conductors of each peg together.

20. An assembly according to any one of claims 15 to 19, characterised in that electrical signals are carried between assemblies by conductive members on the respective bodies.

21. An assembly according to claim 20, characterised in that the body is moulded and in that surfaces of the body are rendered electrically conductive during moulding.

22. An assembly according to claim 20, characterised in

that electrical conductors are embedded in the upper and lower surfaces of the peripheral lip of the body.

23. An assembly according to claim 22, characterised by conductors of opposite polarity.

24. An assembly according to claim 22 or claim 23, characterised in that each conductor is the same shape as the surrounding peripheral lip of the body.

25. An assembly according to any one of claims 22 to 24, characterised in that each conductor has a connector pad at each corner.

26. An assembly according to claim 25, characterised in that the connector pads are adapted to be received by the bores at each corner of the body.

27. An assembly according to any preceding claim, characterised by means suspending the vibration exciter on the body for free movement relative thereto.

28. A loudspeaker characterised by an assembly as claimed in any preceding claim.

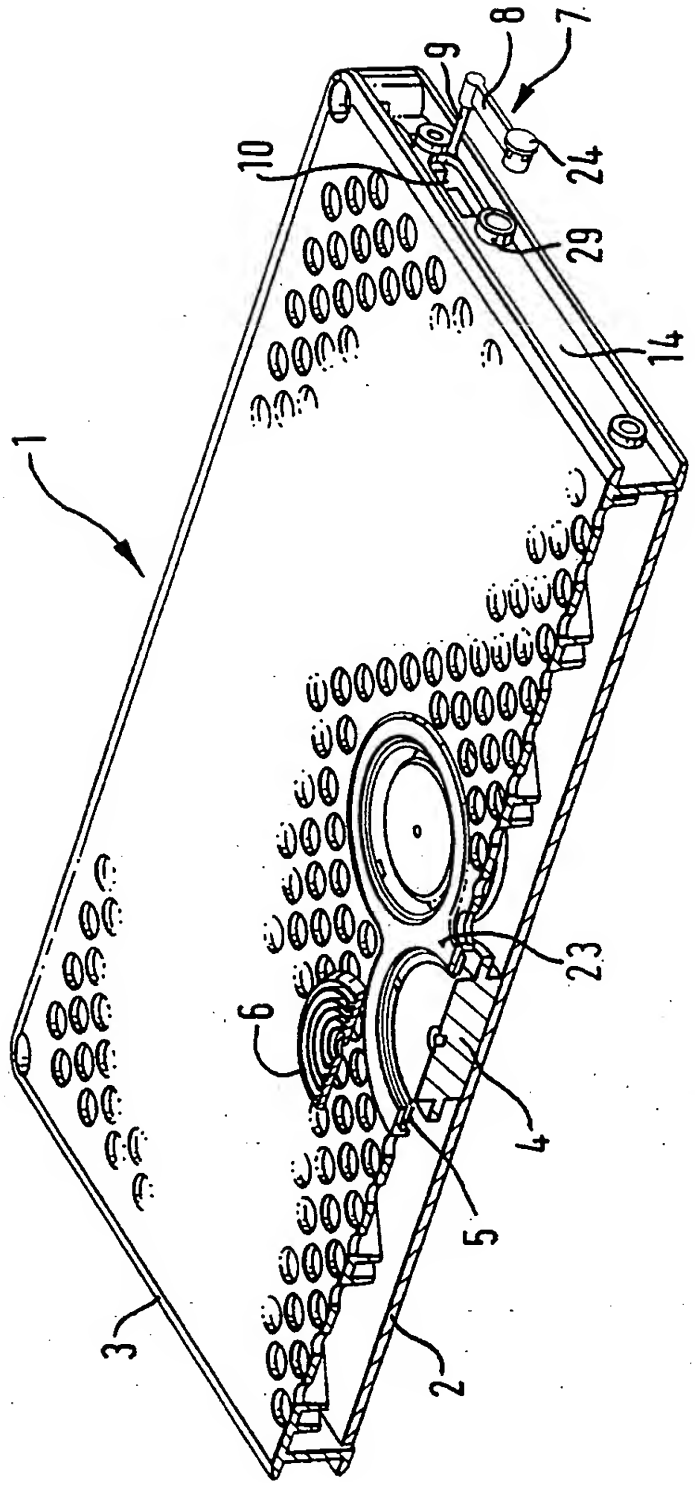


FIG. 1.

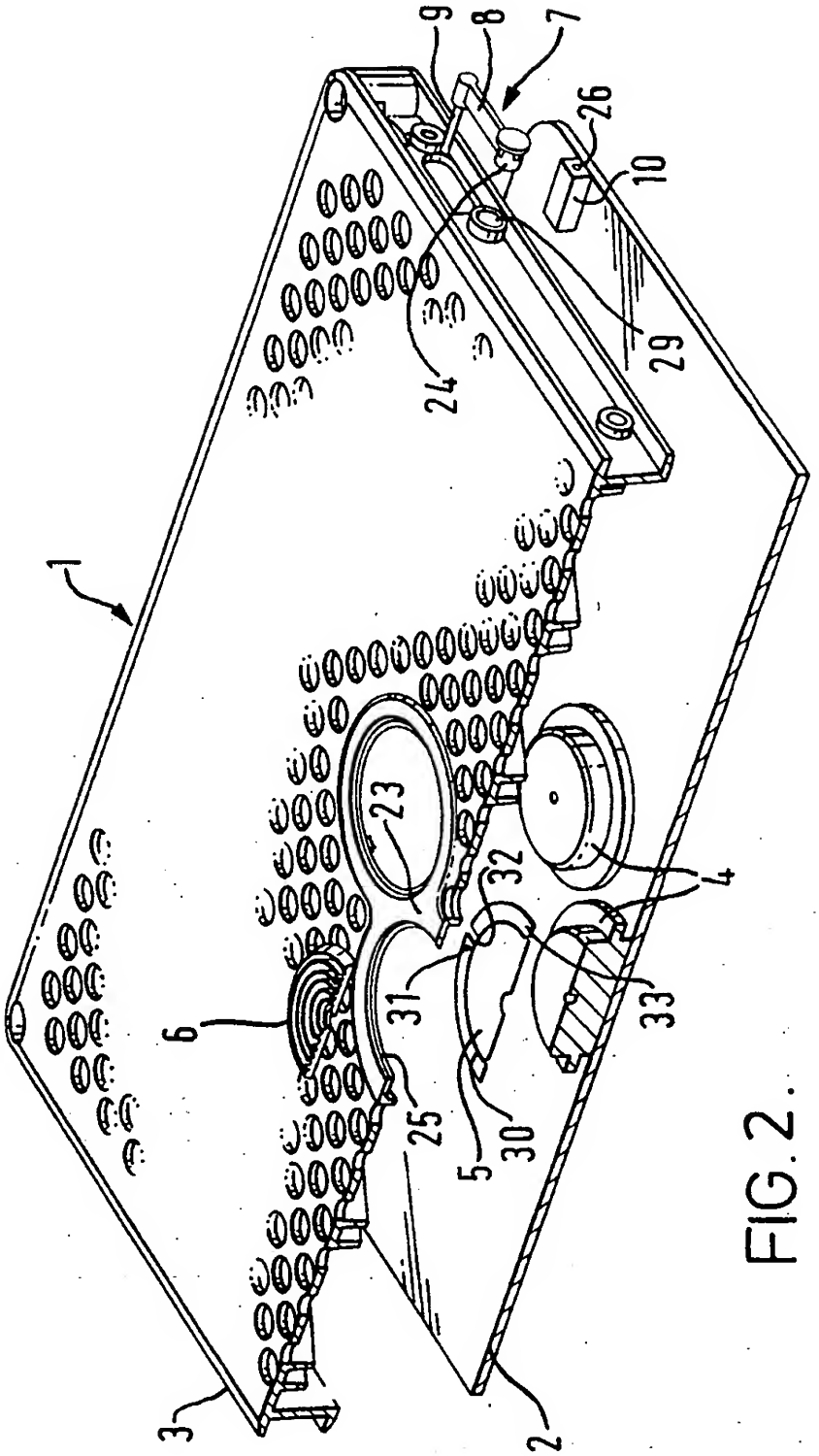


FIG. 2.

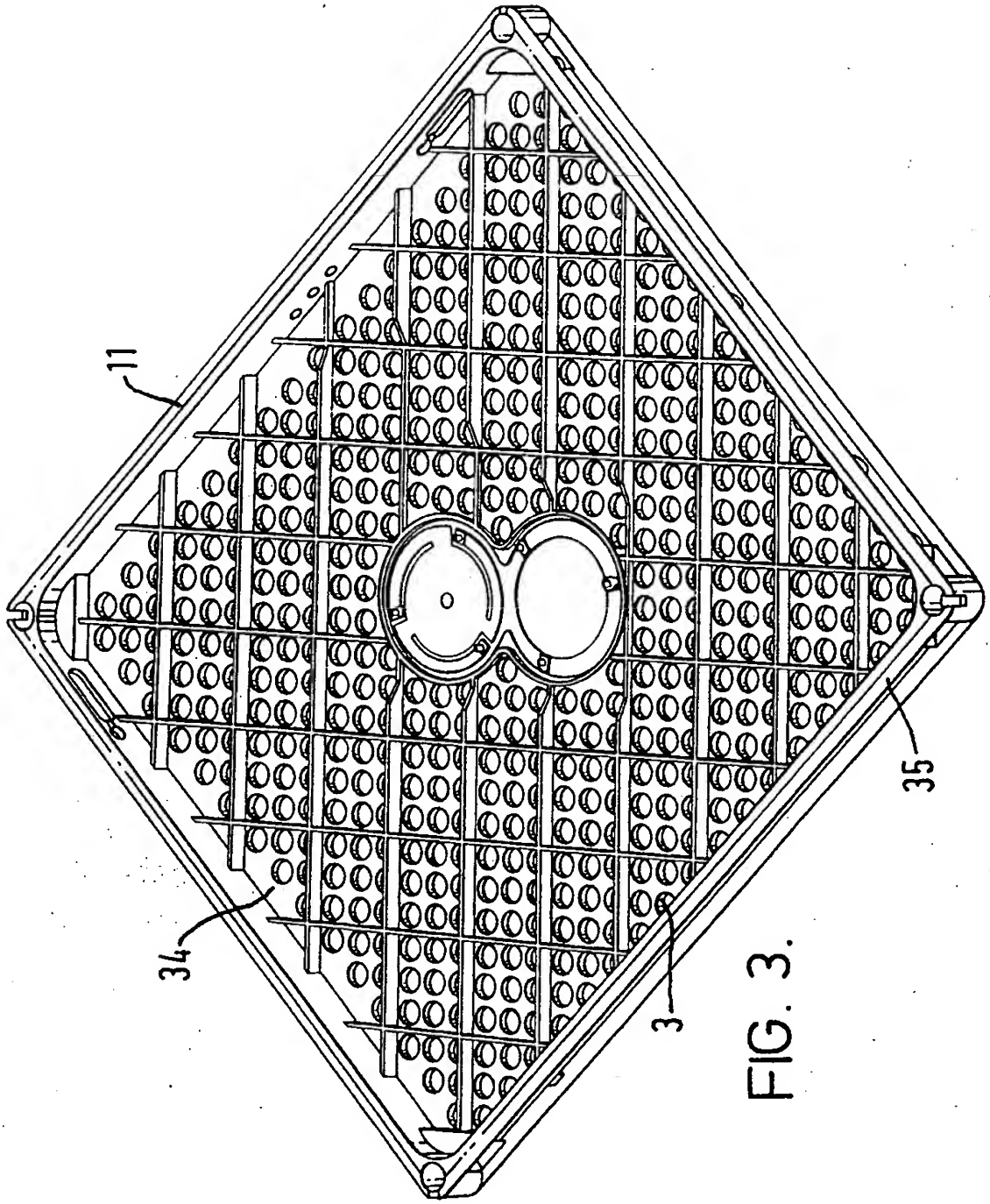


FIG. 3.

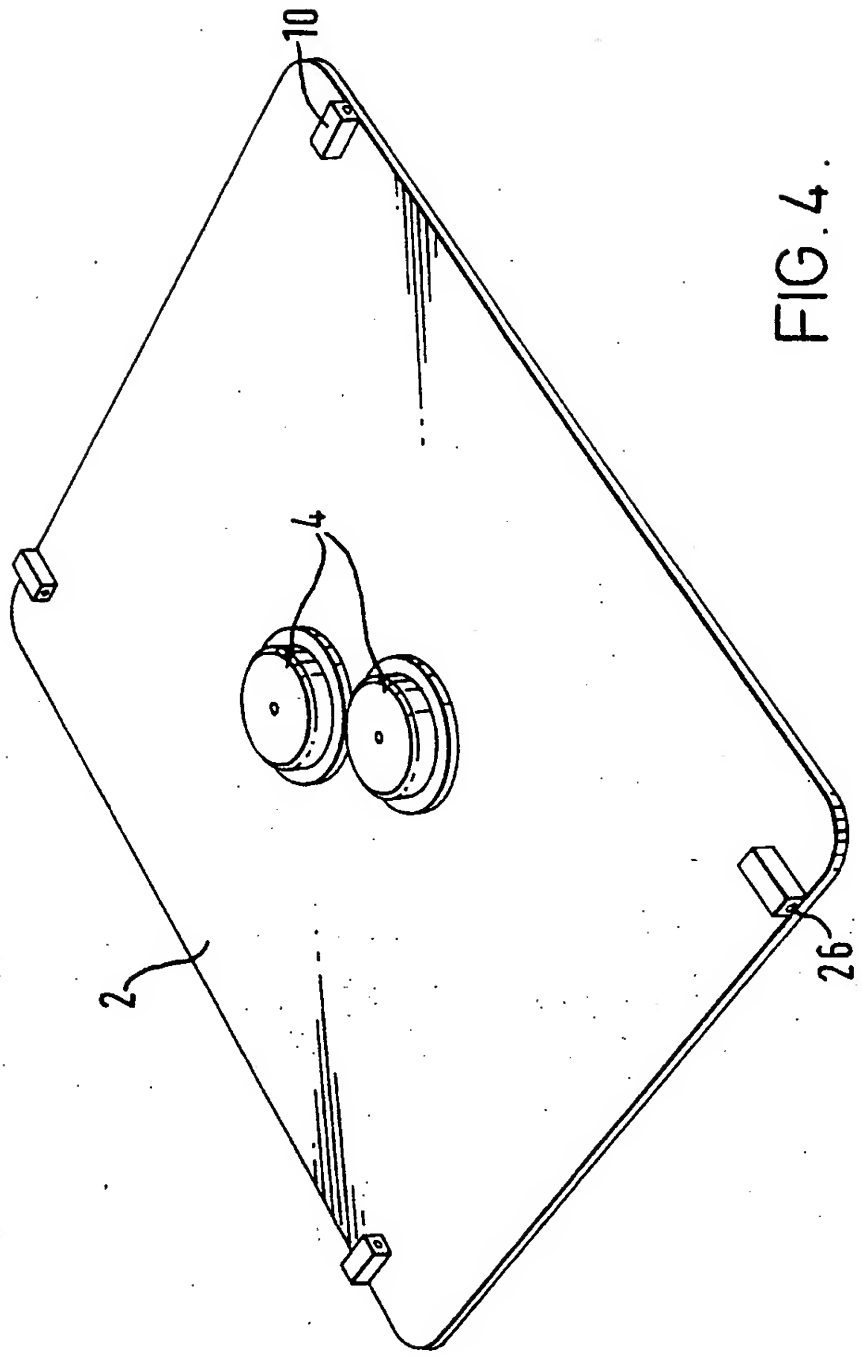


FIG. 4.

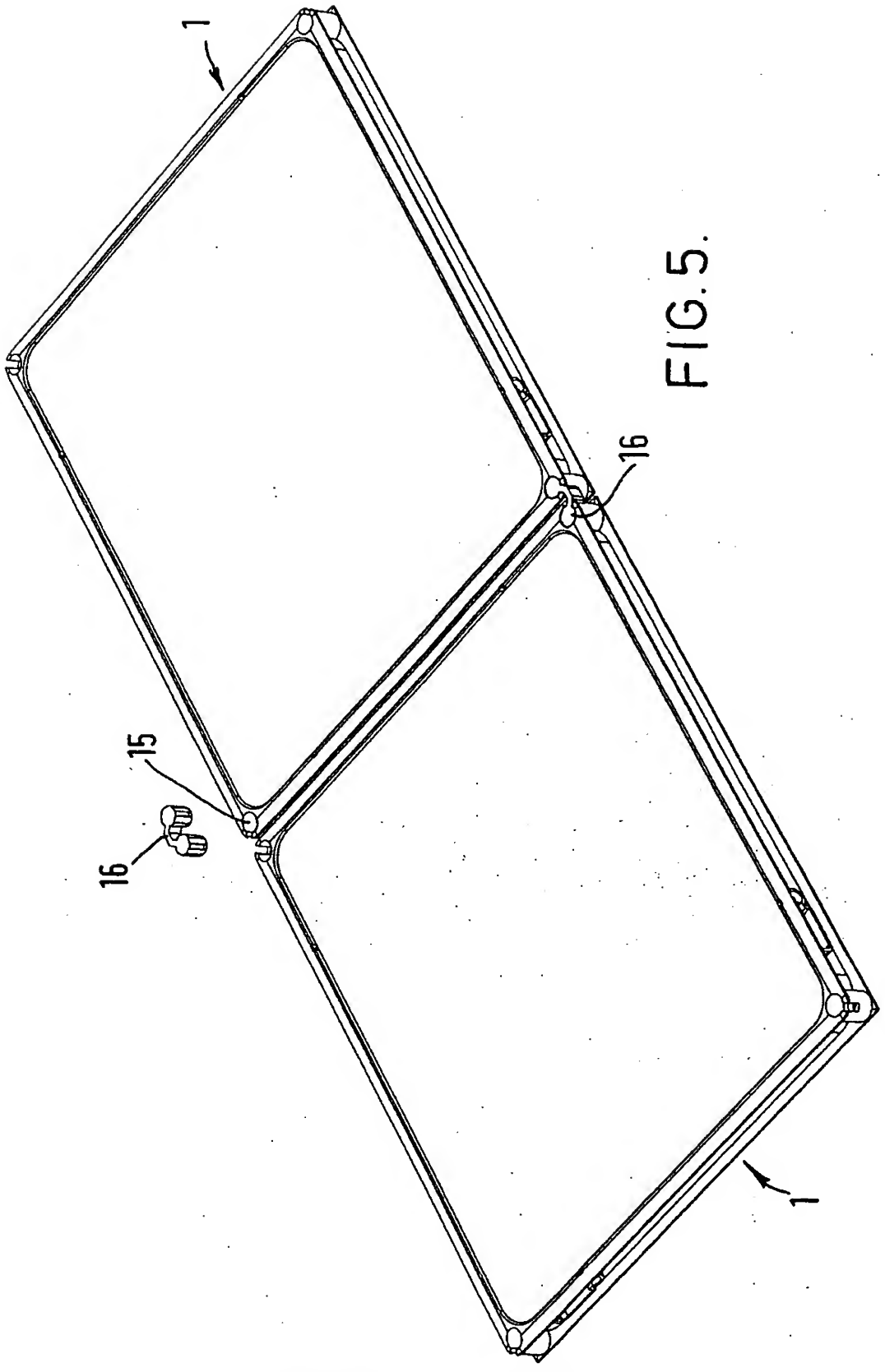
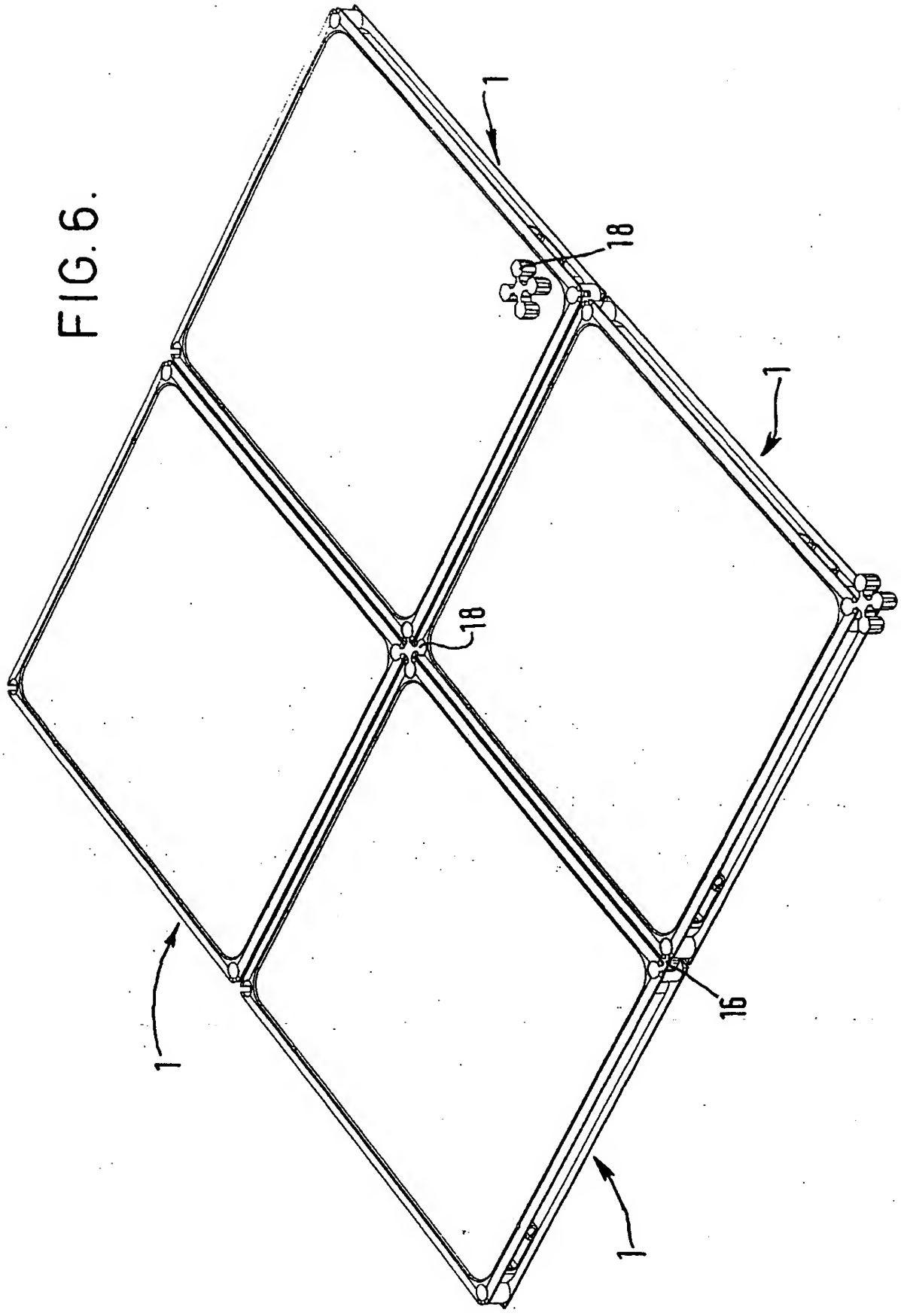


FIG.5.

FIG. 6.



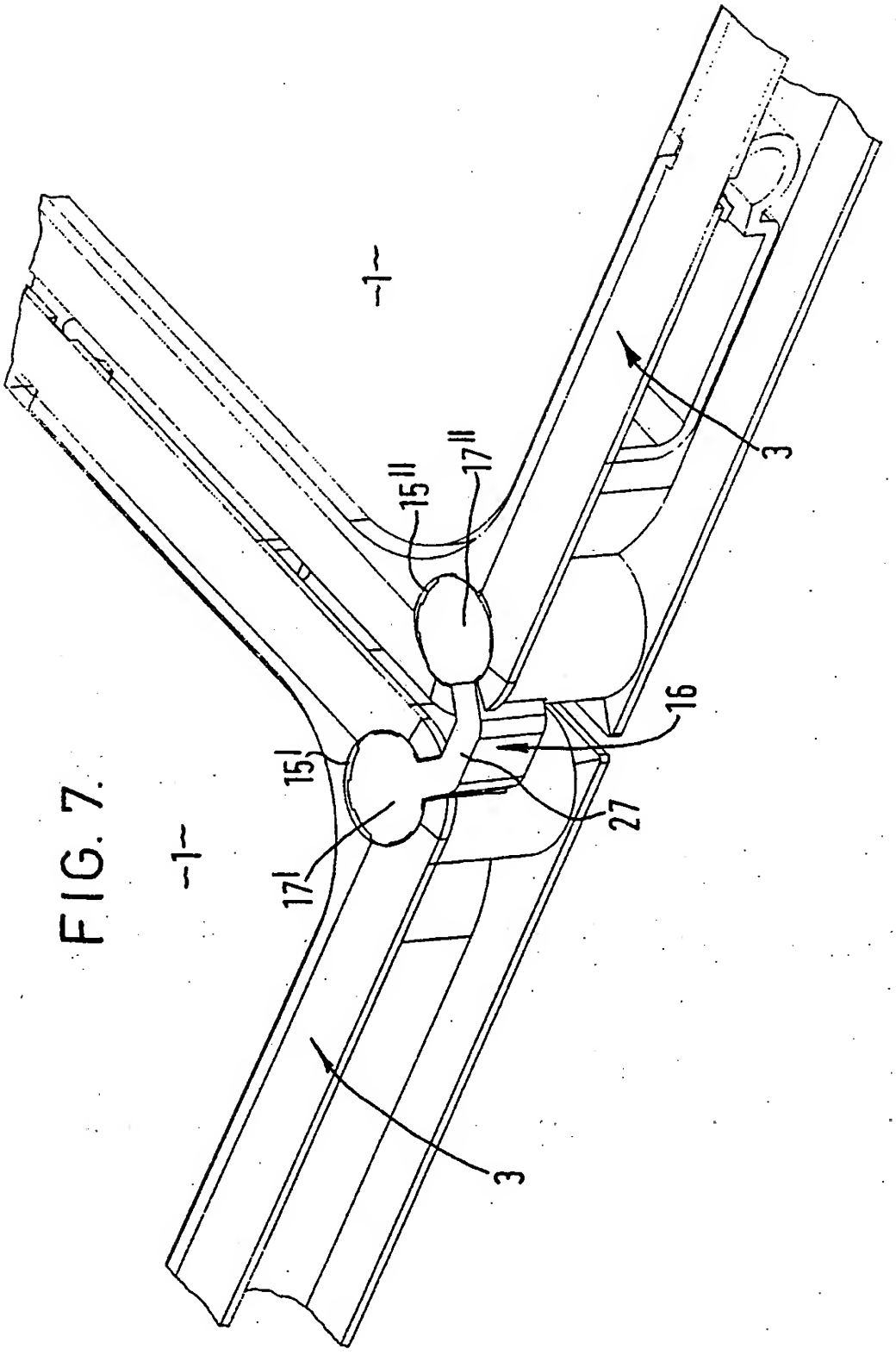


FIG. 7.

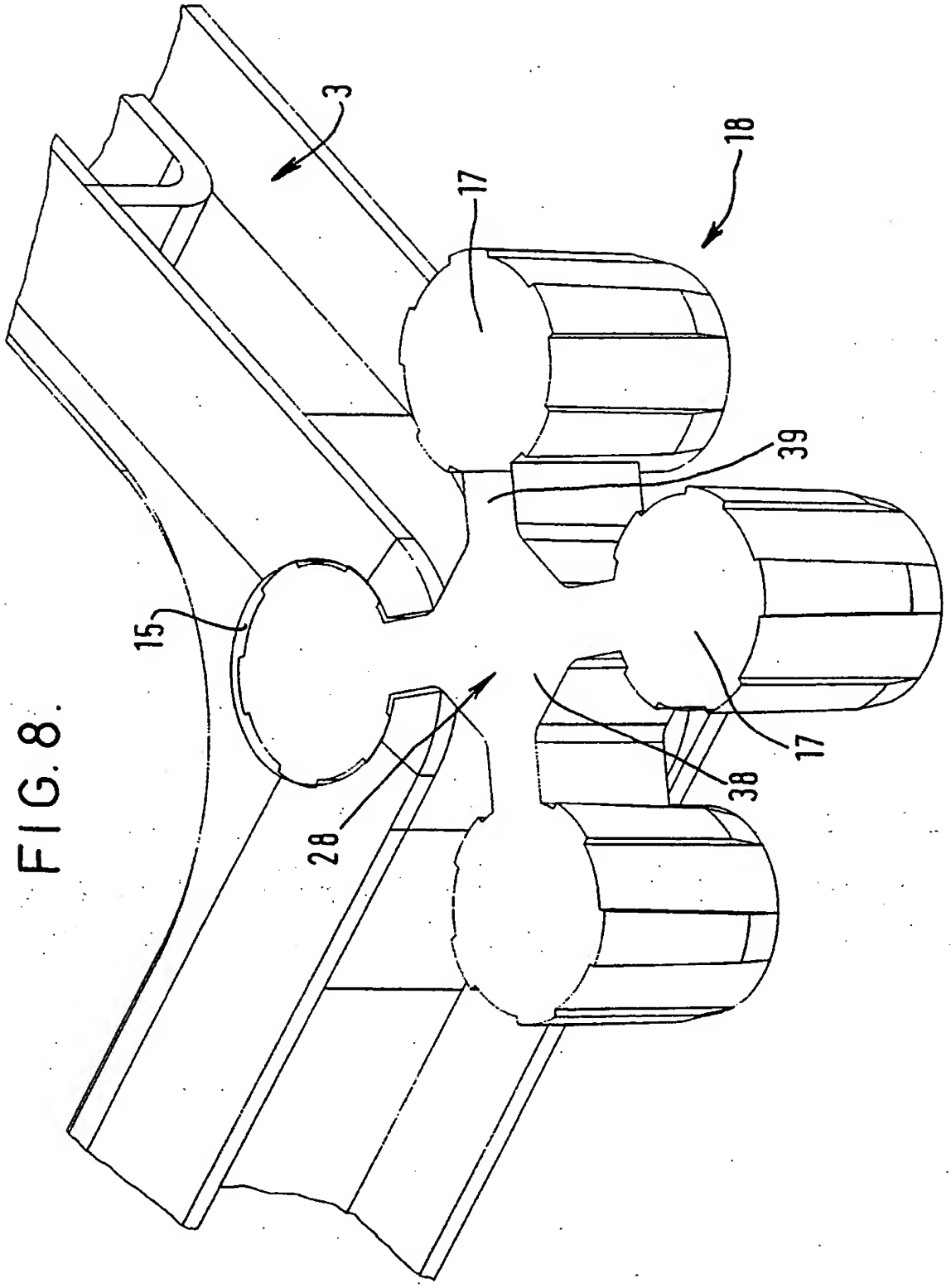


FIG. 8.

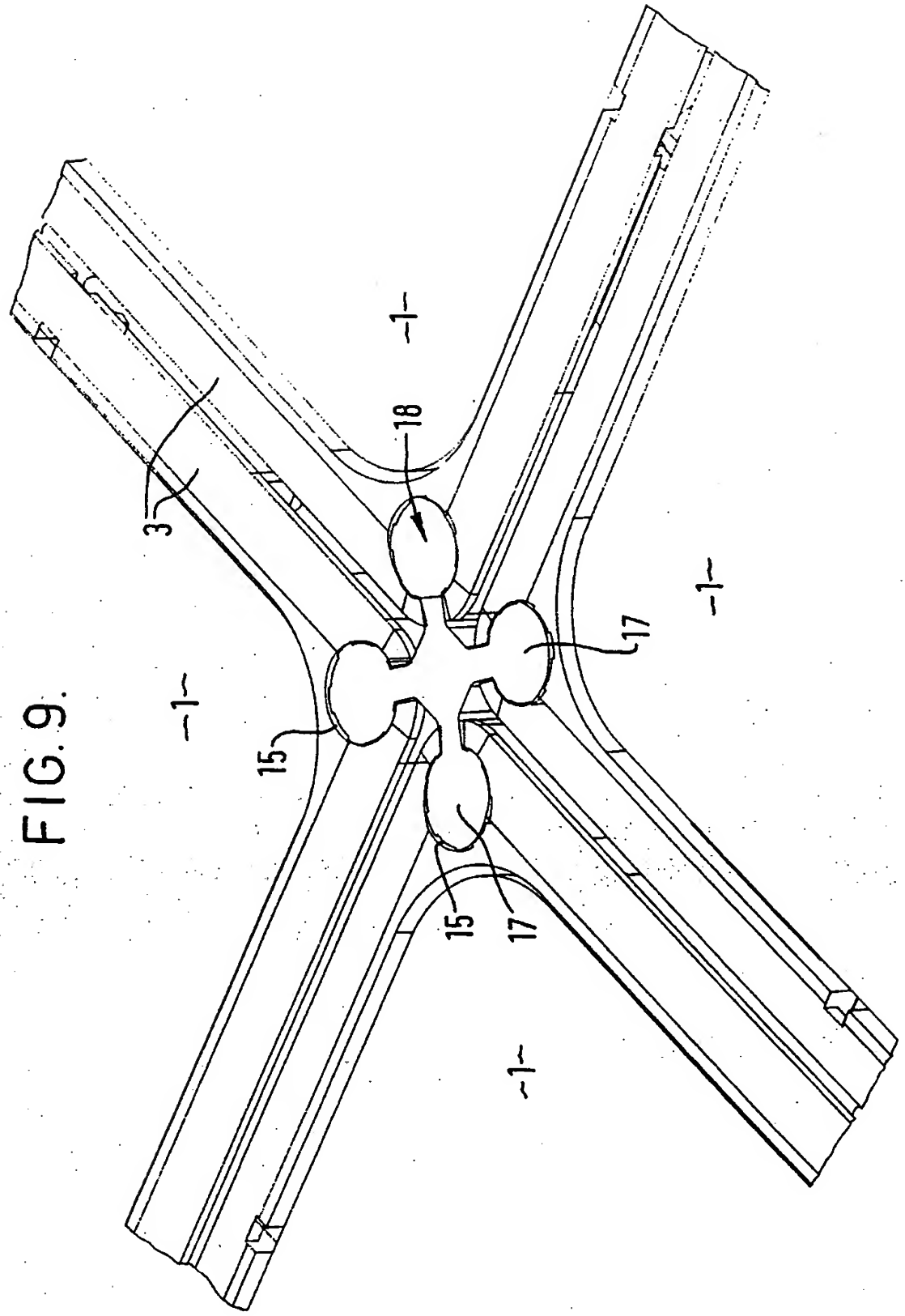


FIG. 9.

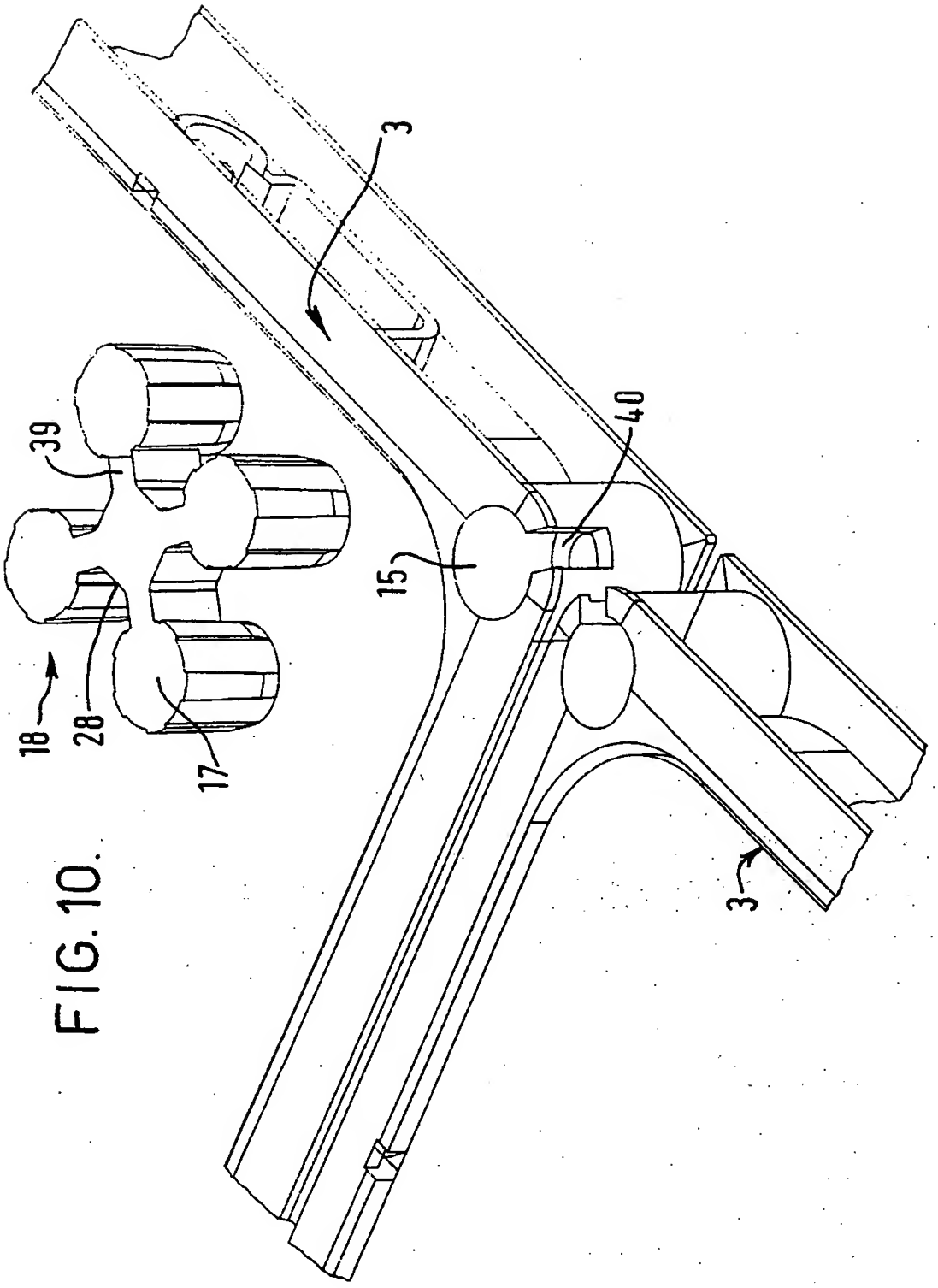


FIG. 10.

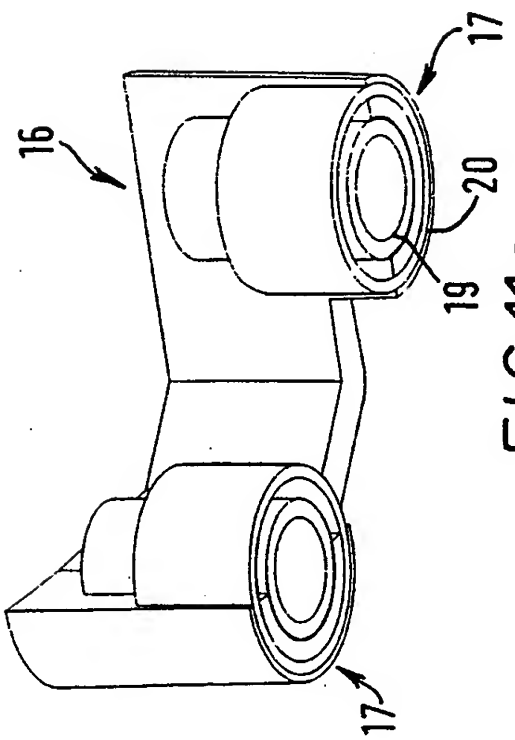


FIG.11c.

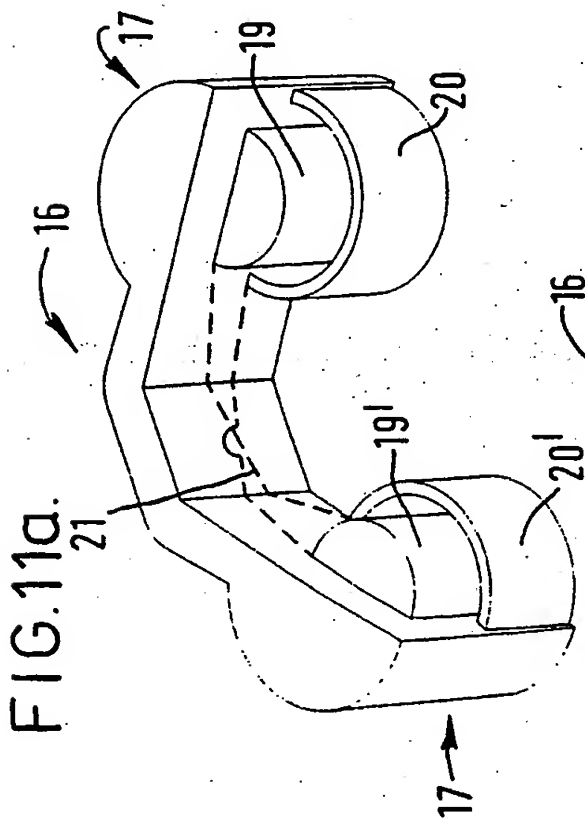


FIG.11a.

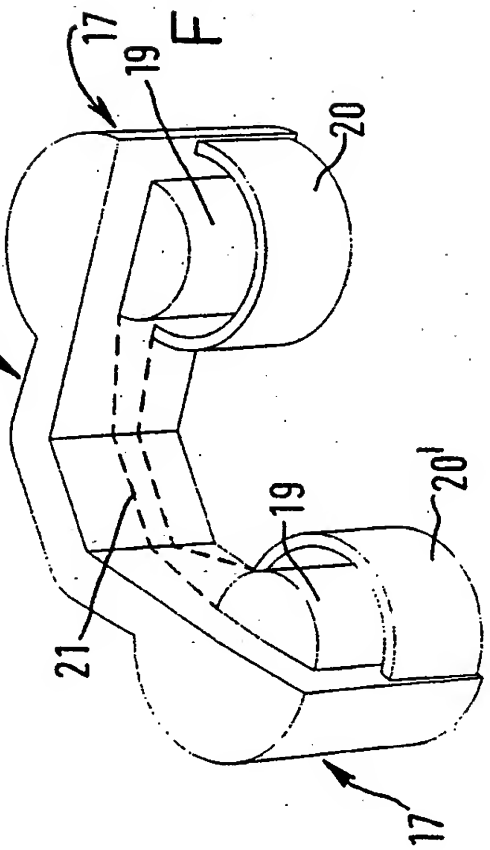


FIG.11b.

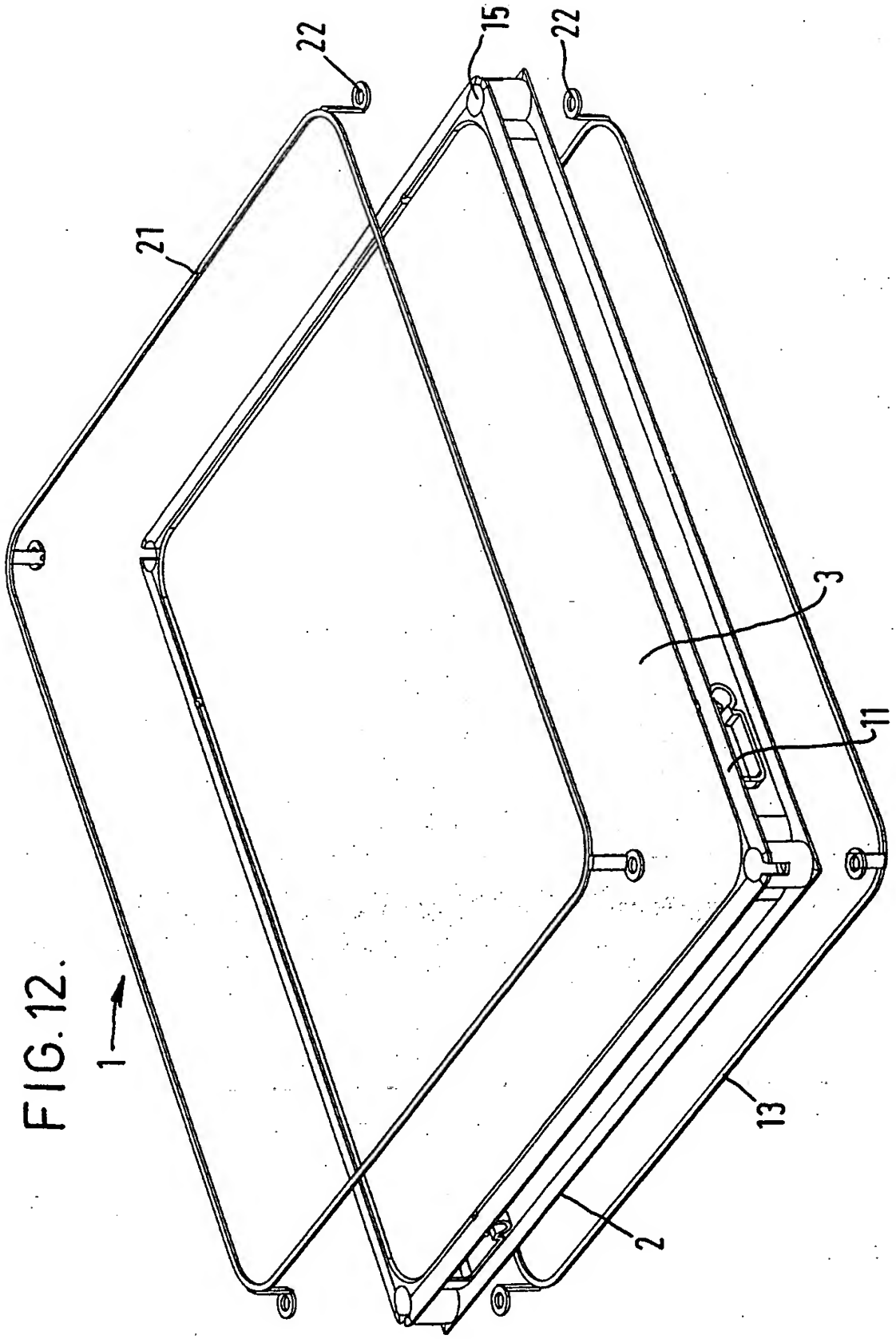


FIG. 12.

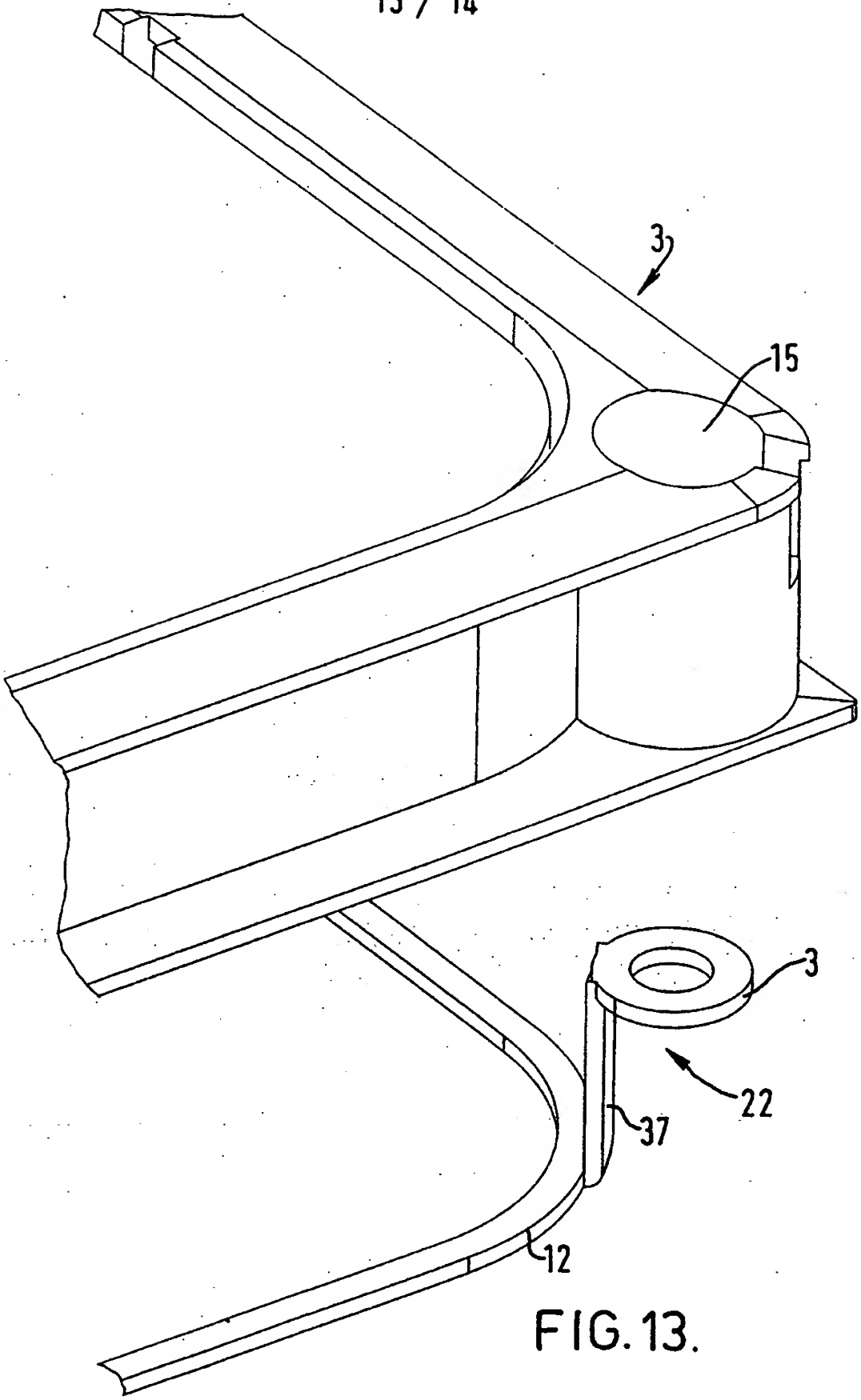


FIG. 13.

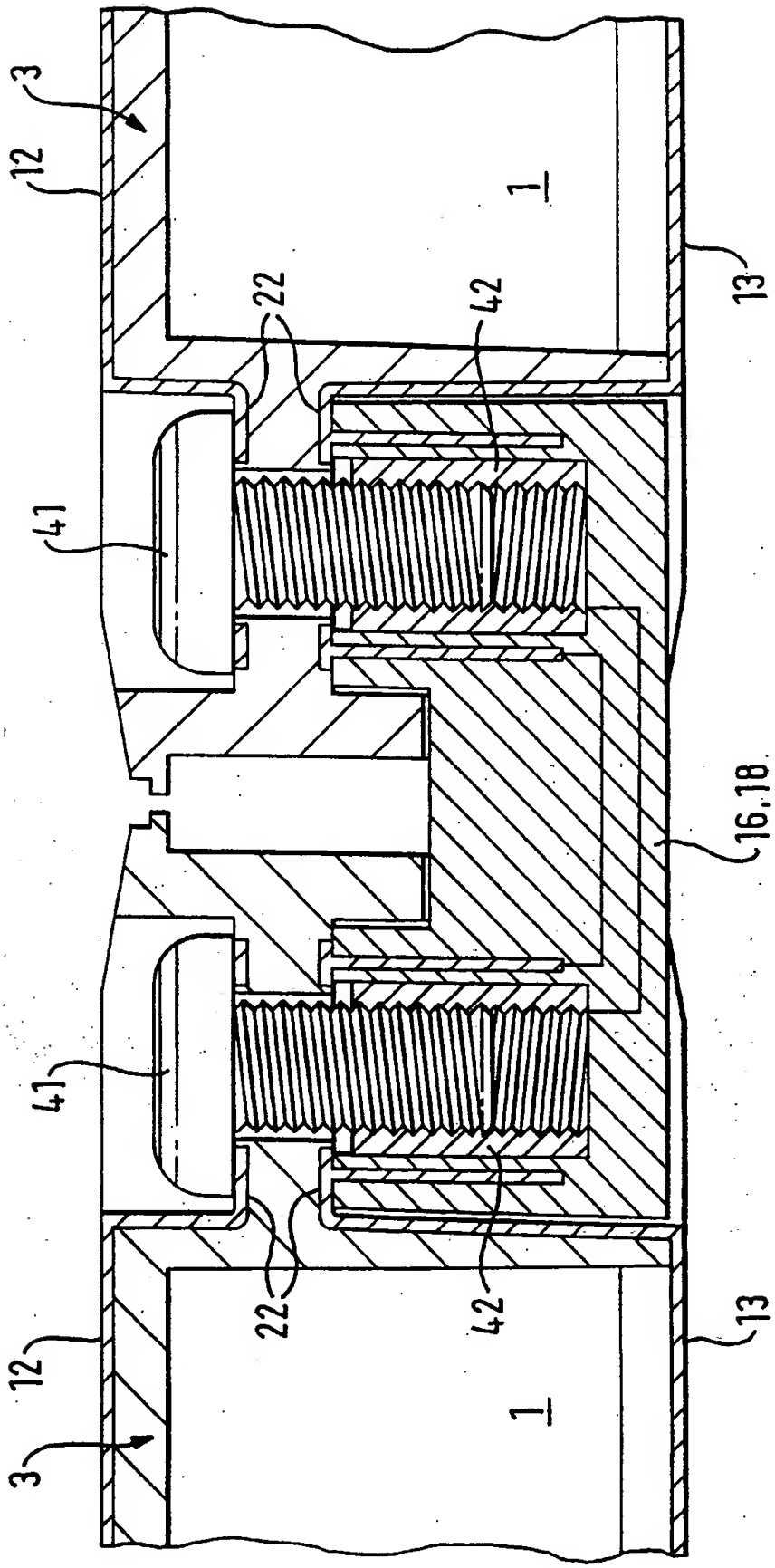


FIG. 14.